Missouri Department of Transportation

Bridge Division

Bridge Design Manual

Section 1.3

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Index of Distribution of Loads

1.3.1 Distribution of Dead Load

Composite Steel or Prestressed Concrete Structures

The dead load applied to the girders through the slab shall be:

Dead Load 1

Non-composite dead loads should be distributed to girders (stringers) on the basis of continuous spans over simple supports.

Dead Load 2

Composite loads shall be distributed equally to all girders. The following are all Dead Load 2 loads:

> Barrier curb
> Future wearing surface on slab
> Sidewalks
> Fences
> Protective coatings and waterproofing on slab

Concrete Slab Bridges

Distribute entire dead load across full width of slab.

For longitudinal design, heavier portions of the slab may be considered as concentrated load for entry into the "Continuous Structure Analysis" computer program.

For transverse bent design, consider the dead load reaction at the bent to be a uniform load across entire length of the transverse beam.

1.3.2 Distribution of Live Load

Live loading to be distributed shall be the appropriate loading shown on the Design Layout.

Applying Live Load to Structure

Superstructure

For application of live load to superstructure, the lane width is considered 10 feet. Each design vehicle has wheel lines which are 6 feet apart and adjacent design vehicles must be separated by 4 feet.

Substructure

To produce the maximum stresses in the main carrying members of substructure elements, multiple lanes are to be loaded simultaneously. The lane width is 10 feet. Partial lanes are not to be considered. Due to the improbability of coincident maximum loading, a reduction factor is applied to the number of lanes. *This reduction however, is not applied in determining the distribution of loads to the stringers*.

AASHTO 3.12

Number of Lanes	Percent
one or two lanes	100
three lanes	90
four lanes or more	75

Distribution of Live Load to Beams and Girders

AASHTO 3.23

Moment Distribution

Moments due to live loads shall not be distributed longitudinally. Lateral distribution shall be determined from AASHTO Table 3.23.1 for interior stringers. Outside stringers distribute live load assuming the flooring to act as a simple span, except in the case of a span with a concrete floor supported by four or more stringers, then AASHTO 3.23.2.3.1.5 shall be applied. In no case shall an exterior stringer have less carrying capacity than an interior stringer.

Shear Distribution

As with live load moment, the reactions to the live load are not to be distributed longitudinally. Lateral distribution of live load shall be that produced by assuming the flooring to act as simply supported. Wheel lines shall be spaced on accordance with AASHTO 3.7.6 and shall be placed in a fashion which provides the most contribution to the girder under investigation, regardless of lane configuration. The shear distribution factor at bents shall be used to design bearings and bearing stiffeners.

Deflection Distribution

Deflection due to live loads shall not be distributed longitudinally. Lateral distribution shall be determined by averaging the moment distribution factor and the number of wheel lines divided by the number of girder lines for all girders. The number of wheel lines shall be based on 10 foot lanes. The reduction in load intensity (AASHTO Article 3.12.1) shall not be applied.

Deflection Distribution Factor = $\dfrac{\{\dfrac{2n}{N}\} + MDF}{2}$

Where: n = number of whole 10 foot lanes on the roadway;
           N = number of girder lines;
           MDF = Moment Distribution Factor.

Example: 38'-0" Roadway (Interior Girder), n=3, N=5, MDF=1.576

Deflection Distribution Factor = $\dfrac{\{\dfrac{2 \; x \; 3lanes}{5 \; girders}\} + 1.576}{2}$ =1.388

Live Load Distribution Factors for Standard Roadway Widths

Roadway Width	Number Girders	Girder Spacing	Exterior Girder			Interior Girder			(1)
			Mom.	Shear	Defl.	Mom.	Shear	Defl.	
26'-0"	4	7'-6"	1.277	1.133	1.139	1.364	1.667	1.182	1.071
28'-0"	4	8'-2"	1.352	1.204	1.176	1.485	1.776	1.243	1.167
30'-0"	4	8'-8"	1.405	1.308	1.453	1.576	1.846	1.538	1.238
32'-0"	4	9'-2"	1.457	1.400	1.479	1.667	1.909	1.584	1.310
36'-0"	5	8'-2"	1.352	1.184	1.276	1.485	1.776	1.343	1.167
38'-0"	5	8'-8"	1.405	1.231	1.303	1.576	1.846	1.388	1.238
40'-0"	5	9'-0"	1.440	1.333	1.520	1.636	1.889	1.618	1.286
44'-0"	5	9'-9"	1.515	1.487	1.558	1.773	1.974	1.687	1.393

(1) Use when checking interior girder moment cyclical loading Case I Fatigue for one lane loading.

Distribution of Live Load to Substructure

For substructure design the live load wheel lines shall be positioned on the slab to produce maximum moments and shears in the substructure. The wheel lines shall be distributed to the stringers on the basis of simple spans between stringers. The number of wheel lines used for substructure design shall be based on 10 foot lanes and shall not exceed the number of lanes times two with the appropriate percentage reduction for multiple lanes where applicable.

In computing these stresses generated by the lane loading, each 10 foot lane shall be considered a unit. Fractional units shall not be considered.

Distribution of Loads to Slabs

AASHTO 3.24.1

For simple spans, the span length shall be the distance center to center of supports but need not be greater than the clear distance plus the thickness of the slab. Slabs for girder and floor beam structures should be designed as supported on four sides.

AASHTO 3.24.6

For continuous spans on steel stringers or on thin flanged prestressed beams (top flange width to thickness ratios > 4.0), the span length shall be the distance between edges of top flanges plus one quarter of each top flange width. When the top flange width to thickness is < 4.0 the span distance shall be the clear span between edges of the top flanges.

AASHTO 3.24.2

When designing the slab for live load, the wheel line shall be placed 1 foot from the face of the barrier curb if it produces a greater moment.

Bending Moments in Slab on Girders

Main Reinforcement Perpendicular to Traffic

AASHTO 3.24.3.1

The load distributed to the stringers shall be

$$\left(\frac{S+2}{32}\right)P20 \text{ or } P25 = \text{Moment in foot-pounds per-foot width of slab.}$$

Where
S = effective span length between girders in feet;
$P20$ or $P25$ = wheel line load for HS20 or HS20 Modified design Truck in kips.

For slabs continuous over 3 or more supports, a continuity factor of 0.8 shall be applied.

Main Reinforcement Parallel to Traffic

AASHTO 3.24.3.2

This distribution may be applied to special structure types when its use is indicated.

Distribution of Live Load to Concrete Slab Bridges

AASHTO 3.24

Live load for transverse beam, column and pile cap design shall be applied as concentrated loads of one wheel line. The number of wheel lines used shall not exceed the number of lanes x 2 with the appropriate reduction where applicable.

AASHTO 3.24.3.2

For slab longitudinal reinforcement design, use live load moment distribution factor of 1/E for a one-foot strip slab with the appropriate percentage reduction.

$E = 4' + 0.06S$, E (max.) = 7'

where:
        E = Width of slab in feet over which a wheel is distributed;
        S = Effective span length in feet.

For slab deflection, use the following deflection factor for a one-foot strip slab without applying percentage reduction.

Deflection Factor = (Total number of wheel line) / (width of the slab)

See also Section 3.52, page 1.7-1 for modulus of elasticity of slab for deflection computation.

1.3.3 Frictional Resistance

The frictional resistance varies with different surfaces making contact. In the design of bearings, this resistance will alter how the longitudinal forces are distributed. The following table lists commonly encountered materials and their coefficients. These coefficients may be used to calculate the frictional resistance at each bent.

Frictional Resistance of Expansion Bearings			
Bearing Type		**Coef.**	**General Data**
Type C Bearing		0.14	Coef. of sliding friction steel to steel = 0.14
6" Diameter Roller		0.01	
Type D Bearing			Coef. for pin and rocker type bearing =
Pin Diameter	**Rocker Radius**		
2"	6.5"	0.0216	$\dfrac{0.14\ (Radius\ of\ pin)}{Radius\ of\ Rocker}$
2"	7"	0.0200	
2"	7.5"	0.0187	
2"	8"	0.0175	Frictional Force =
2"	10.5"	0.0133	Reaction x Coef.
PTFE Bearing		0.0600	

The design of a bent with one of the above expansion bearings will be based on the maximum amount of load the bearing can resist by static friction. When this static friction is overcome, the longitudinal forces are redistributed to the other bents.

The maximum static frictional force at a bent is equal to the sum of the forces in each of the bearings. The vertical reaction used to calculate this maximum static frictional force shall be Dead Loads only for all loading cases. Since the maximum longitudinal load that can be experienced by any of the above bearings is the maximum static frictional force, the effects of longitudinal wind and temperature can not be cumulative if their sum is greater than this maximum static frictional force.

Two conditions for the bents of the bridge are to be evaluated.

1. Consider the expansion bents to be fixed and the longitudinal loads distributed to all of the bents.

2. When the longitudinal loads at the expansion bearings are greater than the static frictional force, then the longitudinal force of the expansion bearings is equal to the dynamic frictional force. It is conservative to assume the dynamic frictional force to be zero causing all longitudinal loads to be distributed to the remaining bents.